Effects of Bark Beetle-Caused Tree Mortality on Subsequent Wildfire

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Photo: J. Hicke

Funding: USFS Western Wildland Environmental Threat Assessment Center

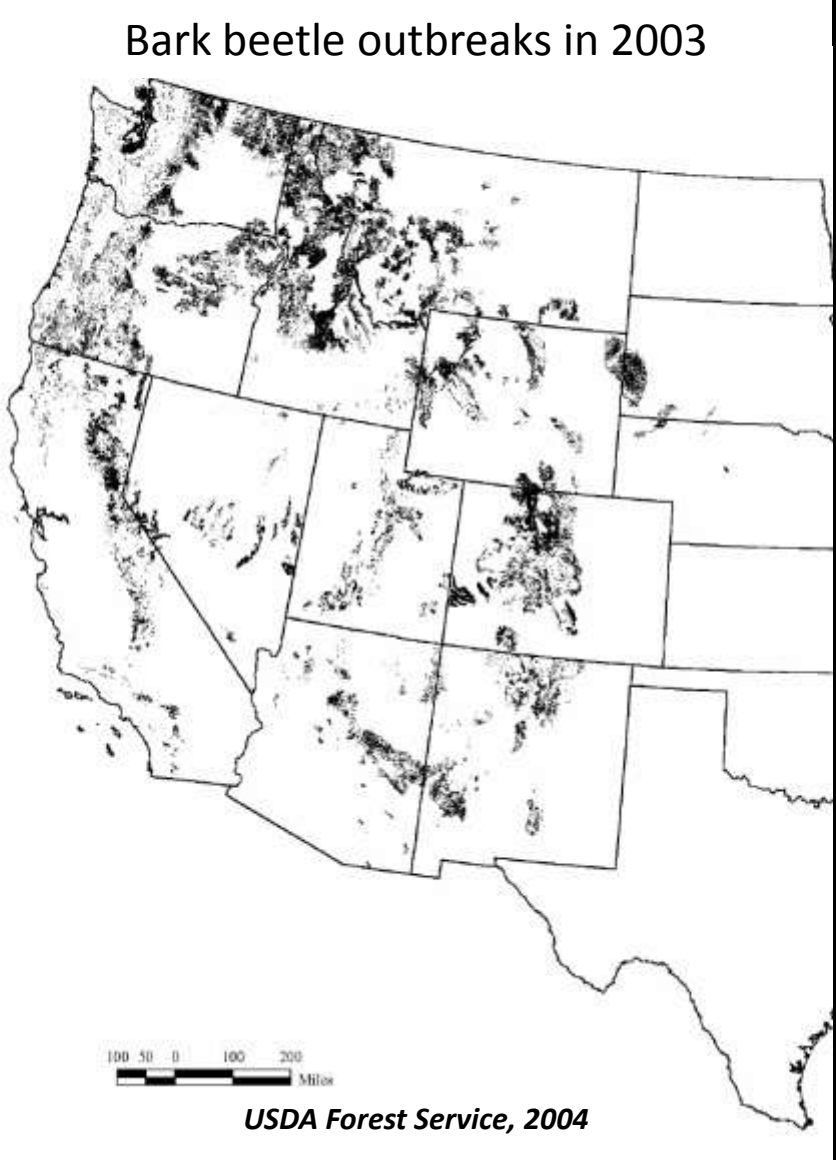
Outline

- Introduction to bark beetles and wildfire
- Review of published literature
  - conceptual framework
  - agreement/disagreement
  - gaps in knowledge
- Summary/conclusions

Photo by Matt Stensland

www.steamboatpilot.com/news/2008/aug/17/dying_forests_increase_wildfire_danger_across_west

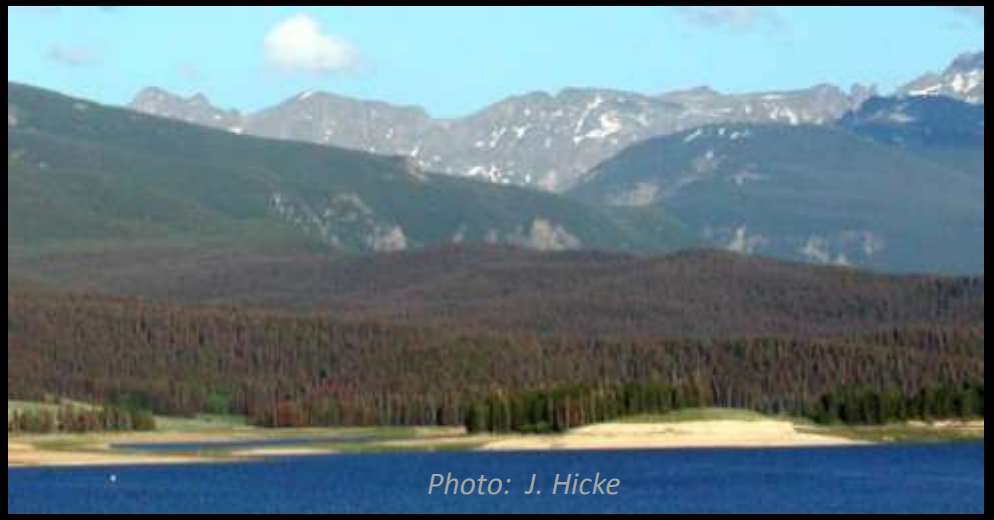
Bark beetle infestations are widespread throughout western US



In 2009,

- 10.6 million acres affected by bark beetles
  - 8.8 million acres affected by mountain pine beetle

For comparison, 3.5 million acres burned in 1988



Bark beetles

- a few species cause most of the tree mortality
  - mountain pine beetle
  - spruce beetle
  - pinyon ips
- native beetles
  - responding to climate change
- size of grain of rice
- hosts: conifers
- hosts have defenses

Stages following bark beetle attack

1. “Red-attack” stage

- for 3-5 years after attack
- dead tree, needles on

Stages following bark beetle attack

2. “Gray-attack” stage

- for 5-10? 15? years after attack
- needles off trees
- trees remain standing

Stages following bark beetle attack

3. “Old-attack” stage

- beginning one to several decades after attack
- trees fall
- new trees establish and grow

Review of published literature

Objectives

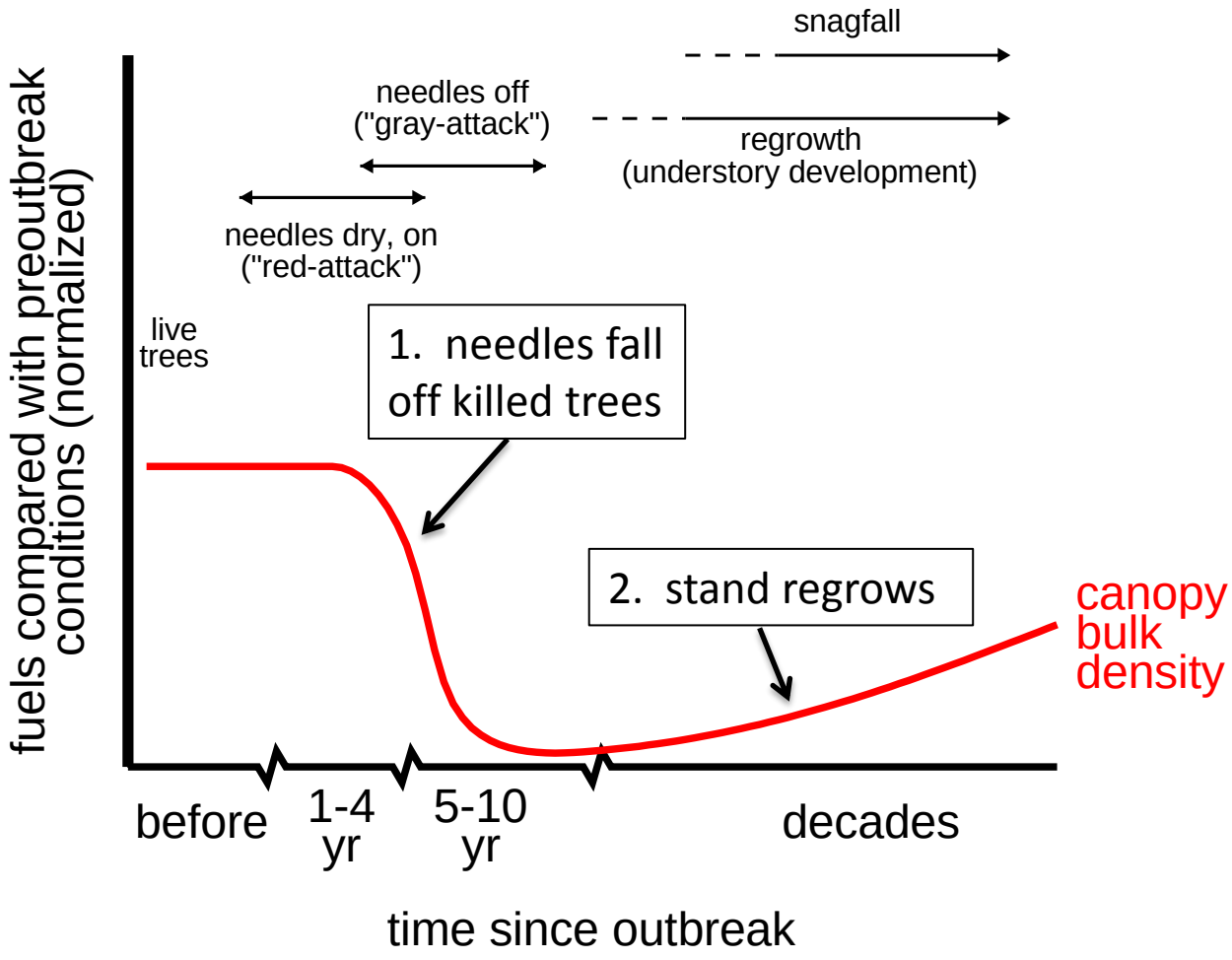
- updated review of literature
- develop conceptual framework
  - expected changes to fuels/fire
  - created from
    - published literature
    - scientific understanding
  - stands of trees
  - stands have trees in same condition
- agreement/disagreement of literature
- gaps in knowledge

Photo by Matt Stensland

www.steamboatpilot.com/news/2008/aug/17/dying_forests_increase_wildfire_danger_across_west

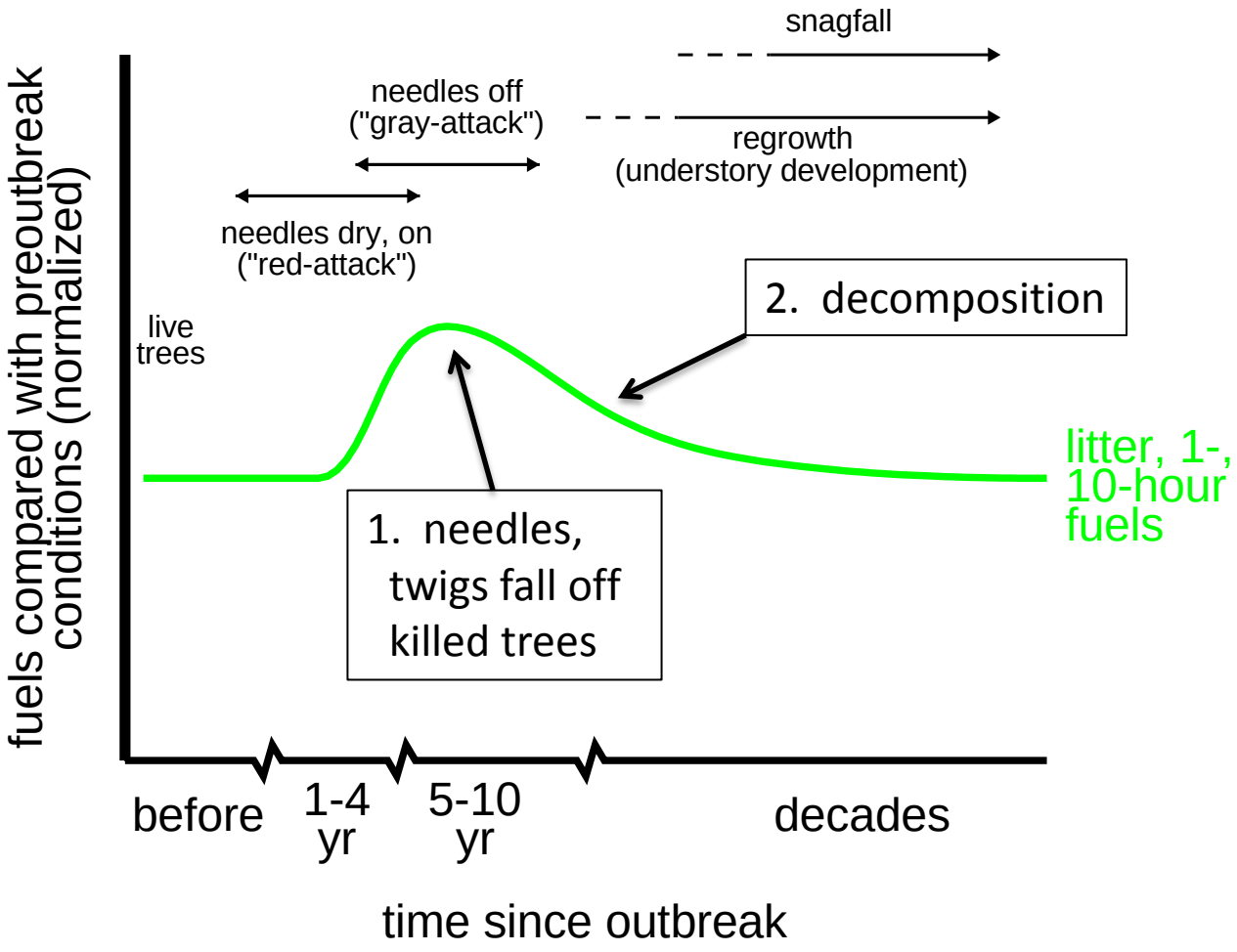
Expected fuel patterns

Canopy bulk density: Amount of fuel in canopy



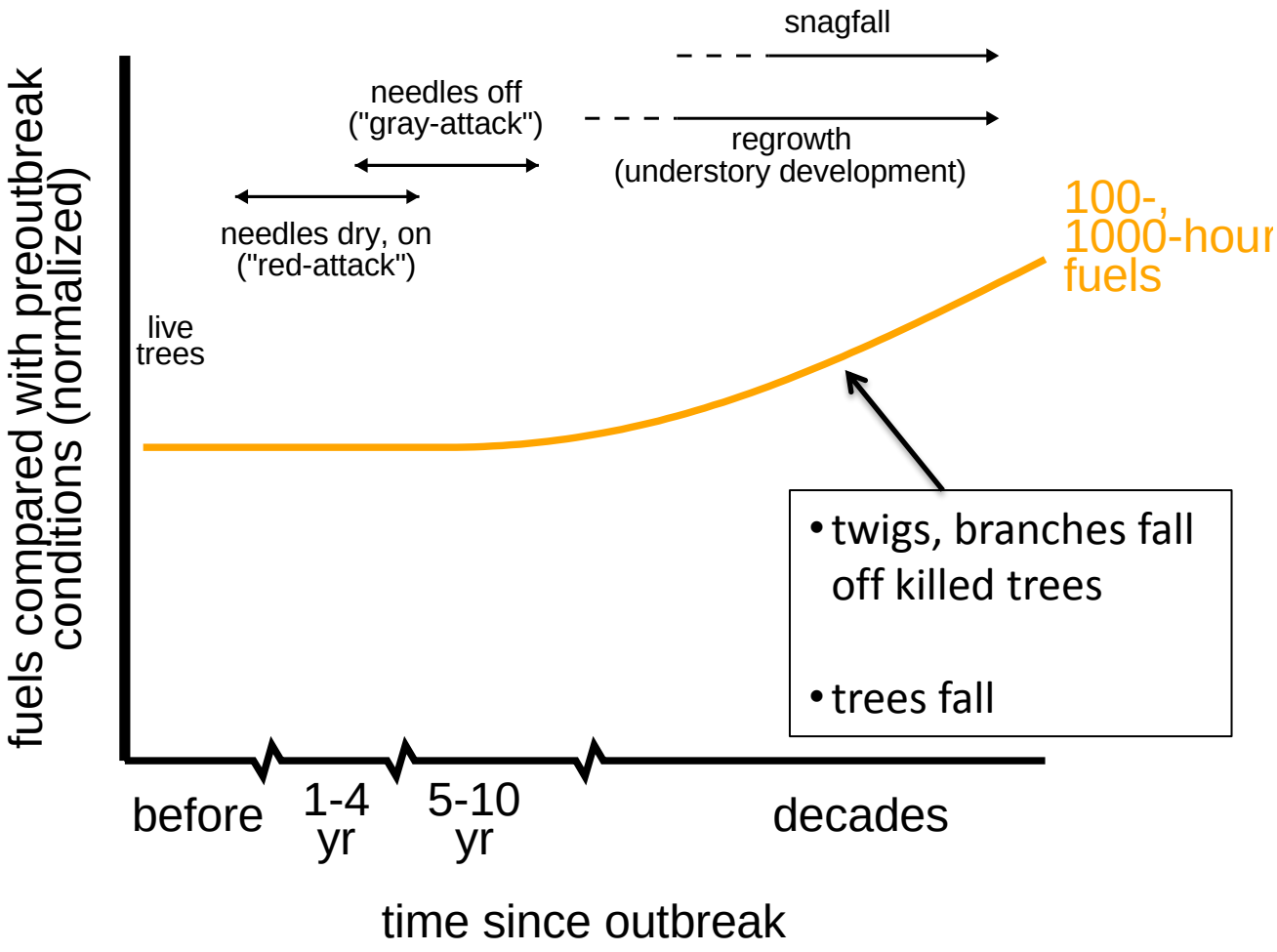
Expected fuel patterns

Fine fuels: litter, dead woody fuels <1" diameter (surface)



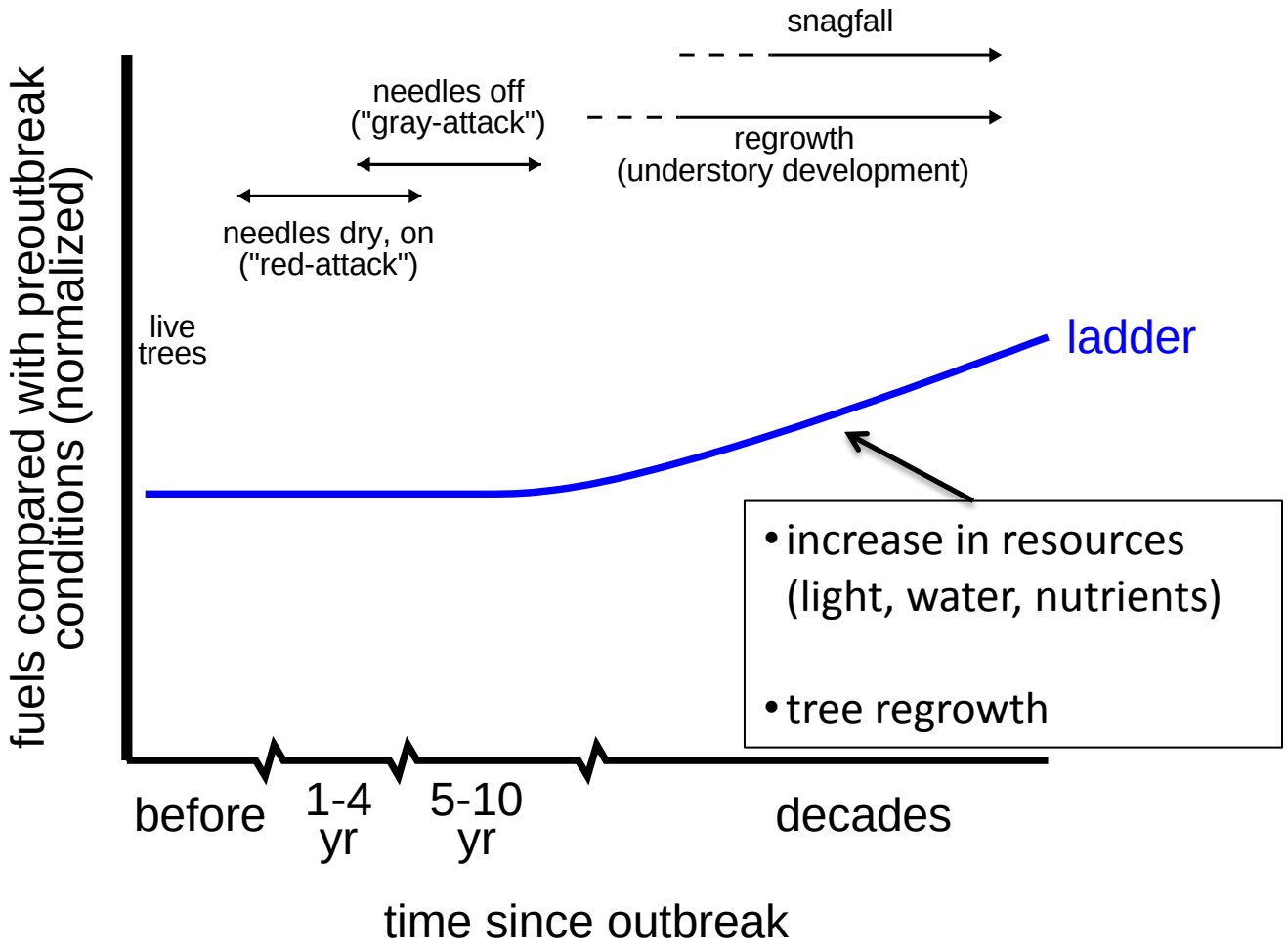
Expected fuel patterns

Coarse fuels: dead woody fuels >1" diameter (surface)



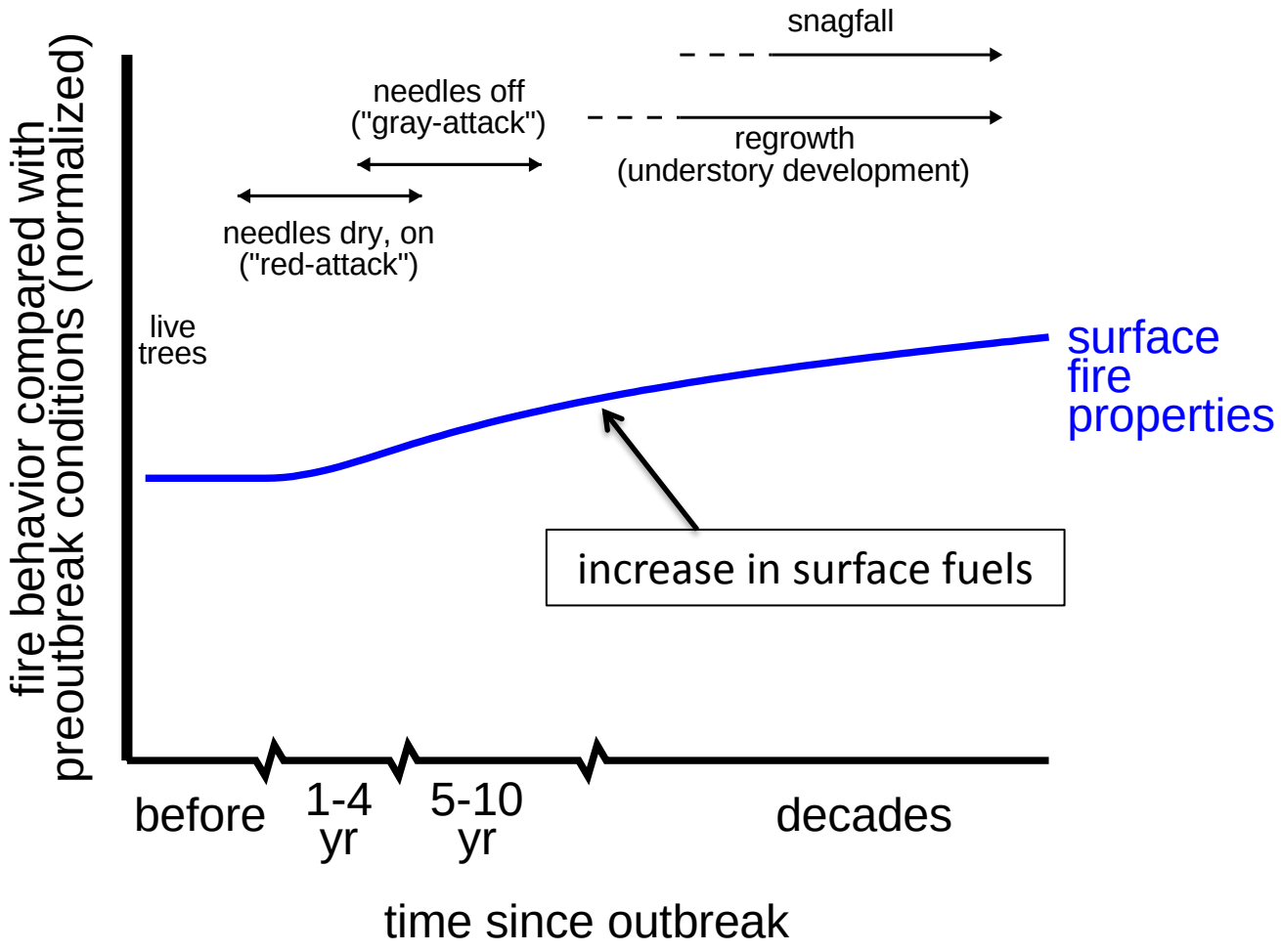
Expected fuel patterns

Ladder fuels: herbs, shrubs, seedlings/saplings



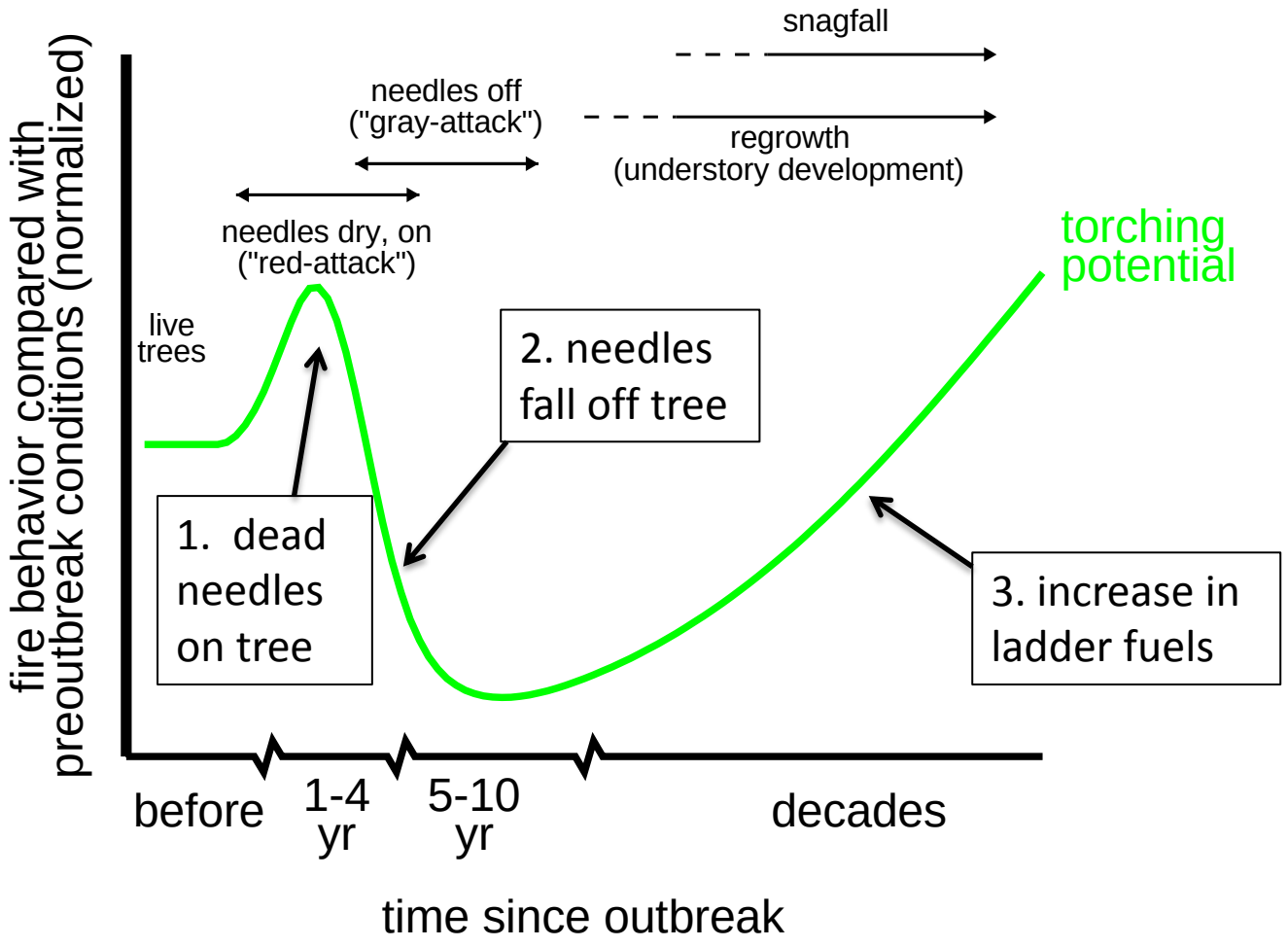
Expected fire behavior patterns

Surface fire properties: rate of spread, fireline intensity (energy release), flame length



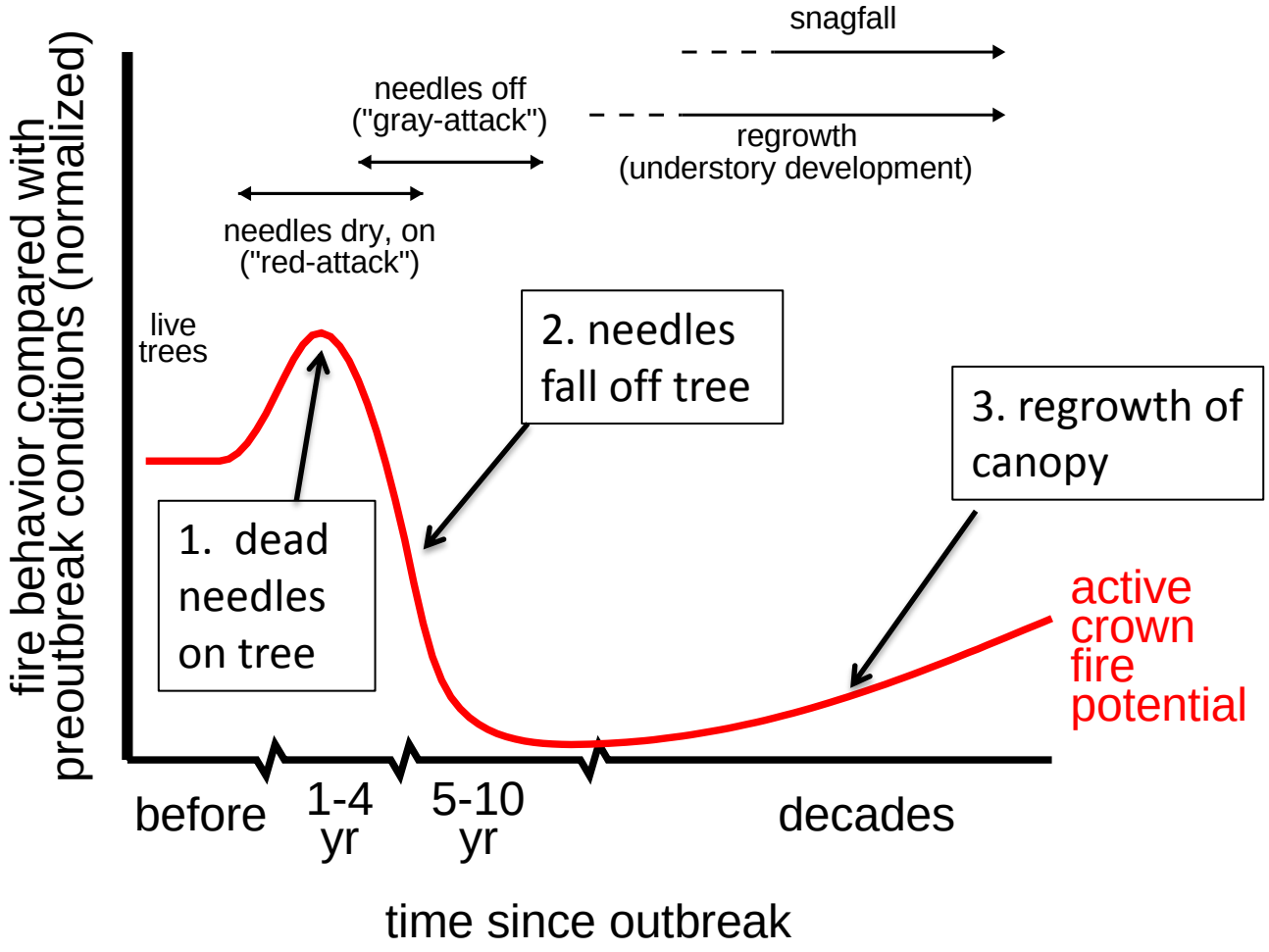
Expected fire behavior patterns

Torching: surface fire igniting a tree or group of trees

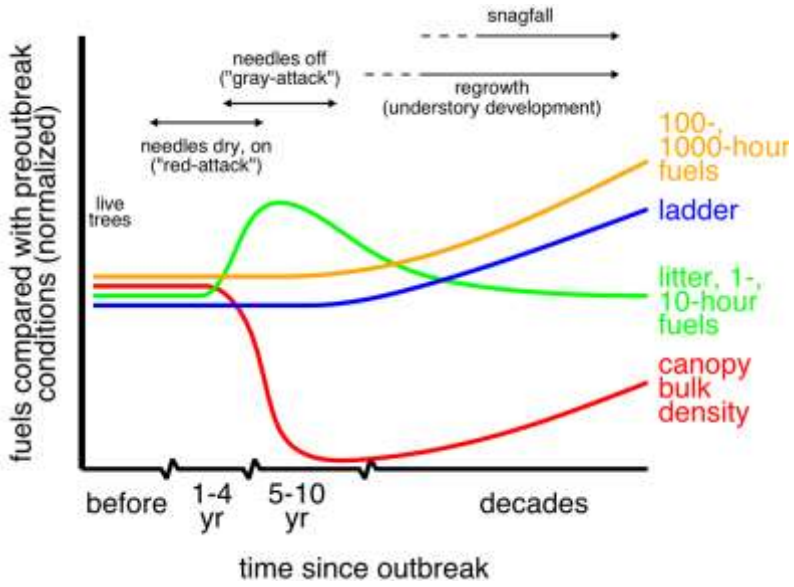


Expected fire behavior patterns

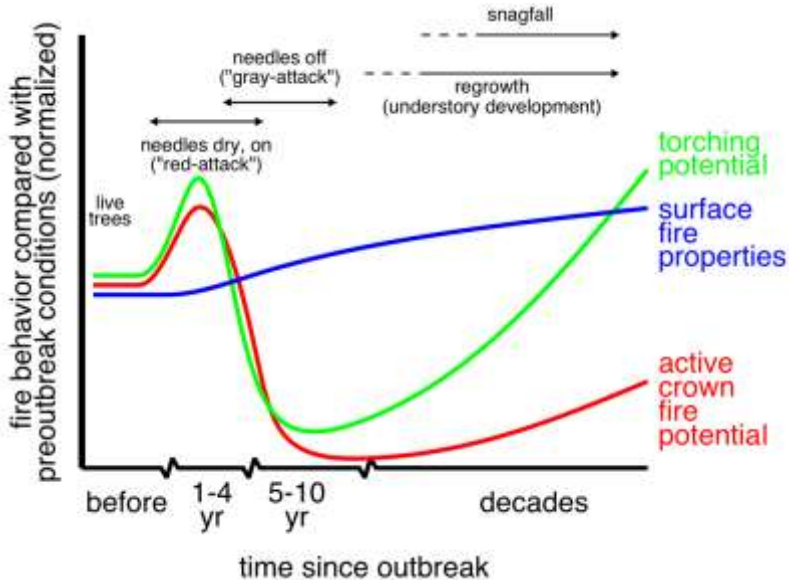
Active crown fire: spread in canopy



Fuel characteristics



Fire characteristics

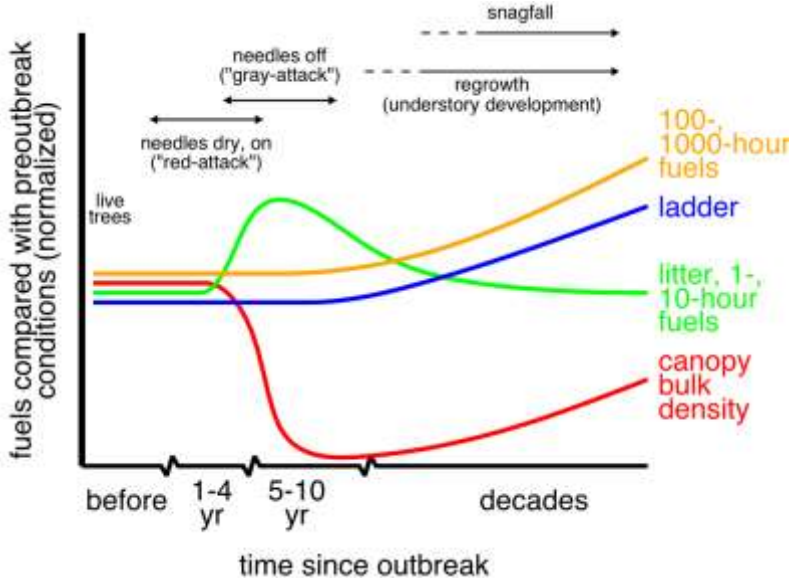


Key ideas of conceptual framework

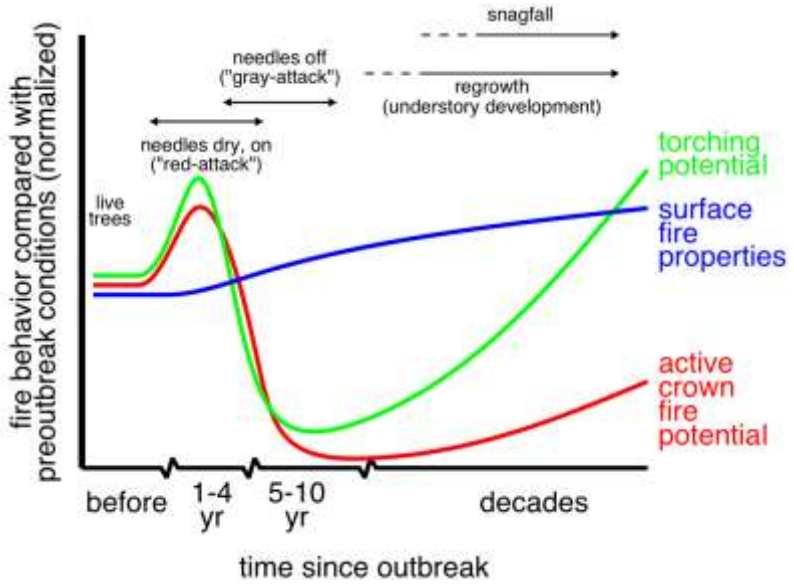
- large variability in responses among characteristics
- characteristics are increasing or decreasing at different times

Specifying time since disturbance and fuel/fire characteristic are critical when discussing effects

Fuel characteristics



Fire characteristics



So how much does the published literature support this conceptual framework?

Confidence in conceptual framework

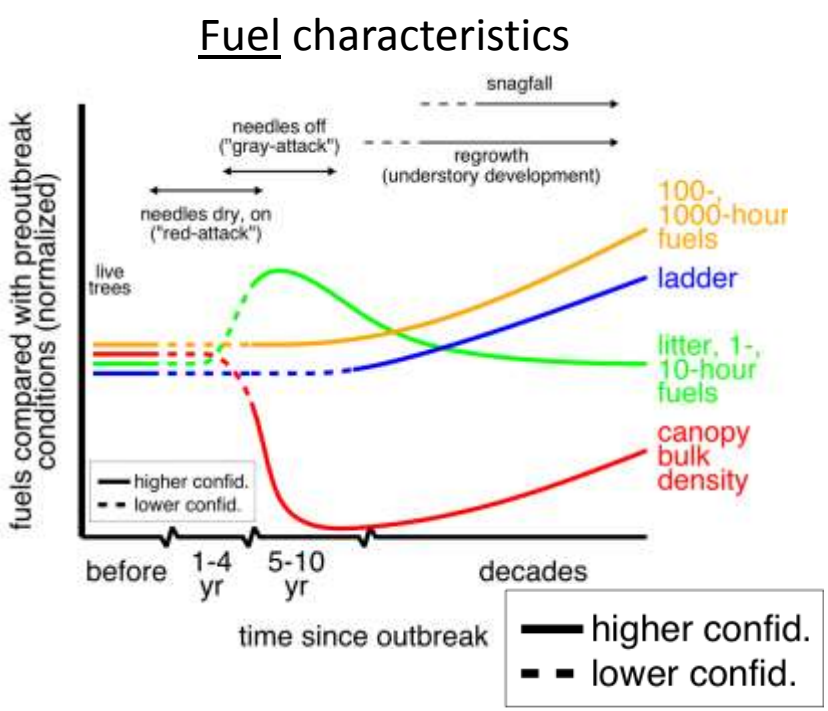
<u>higher confidence</u>:

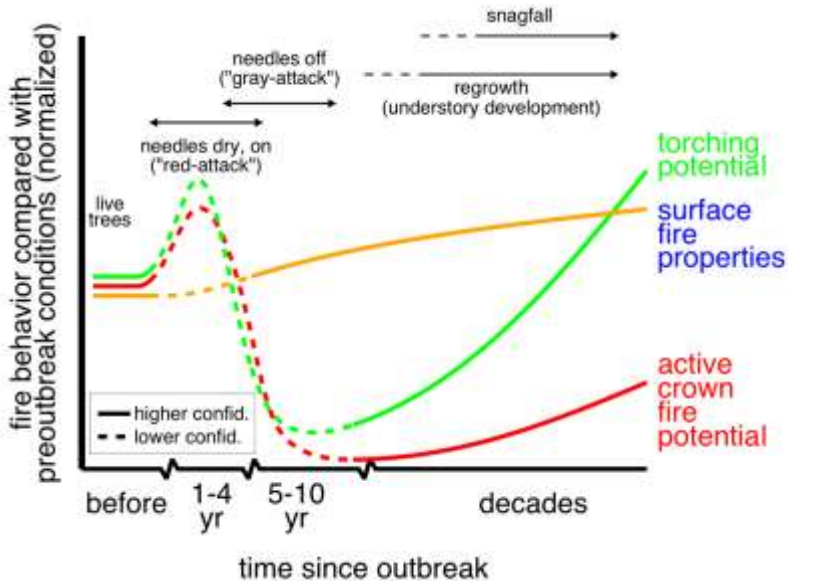
- more studies (replication)
- agreement among studies

<u>lower confidence</u>:

- fewer (or no) studies
- disagreement among studies
  - with other studies
  - with conceptual framework

Confidence in the conceptual framework



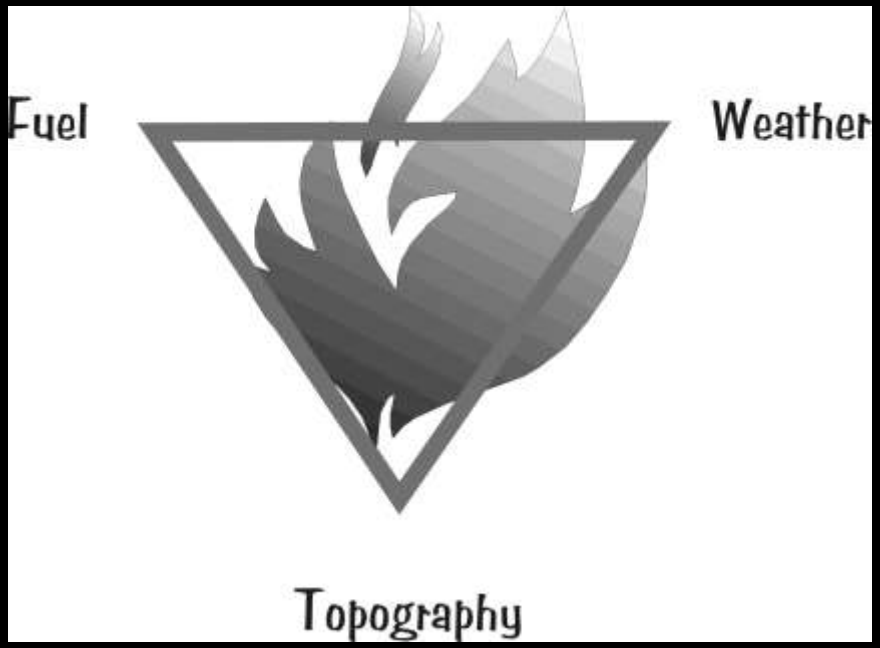


- higher confidence in old-attack stage: more studies and agreement
- lower confidence in red- and gray-attack stage: disagreement
  - fuels
  - torching, active crown fire
  - fewer studies in red-attack
- also, lower confidence in probability of occurrence in red-attack stage

Potential explanations for disagreement among studies and with conceptual framework

1. Studies of fire occurrence/severity need to include all drivers

- beetle outbreaks
- fuel moisture
- topography
- wind speed, direction
- ignition location
- prefire fuel amounts



http://warnercnr.colostate.edu/avprojects/00proj/fujisawa/web_docs/intro.html

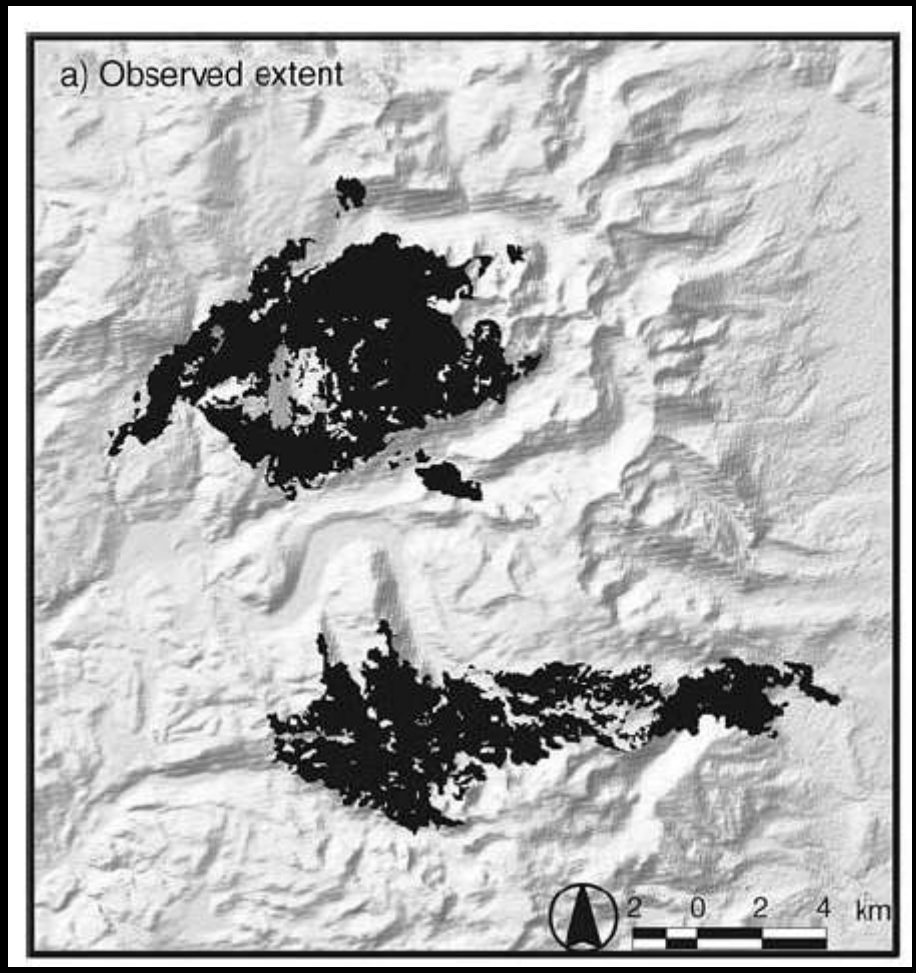
Potential explanations for disagreement among studies and with conceptual framework

2. Studies ask different questions
   a) what are the most important drivers of wildfire characteristics?

Kulakowski and Veblen 2007

- considered several drivers of fire extent and severity
  - forest type, percent crown cover, topography, blowdown, beetle outbreaks, previous fire

- found that presence of beetle outbreaks was not important

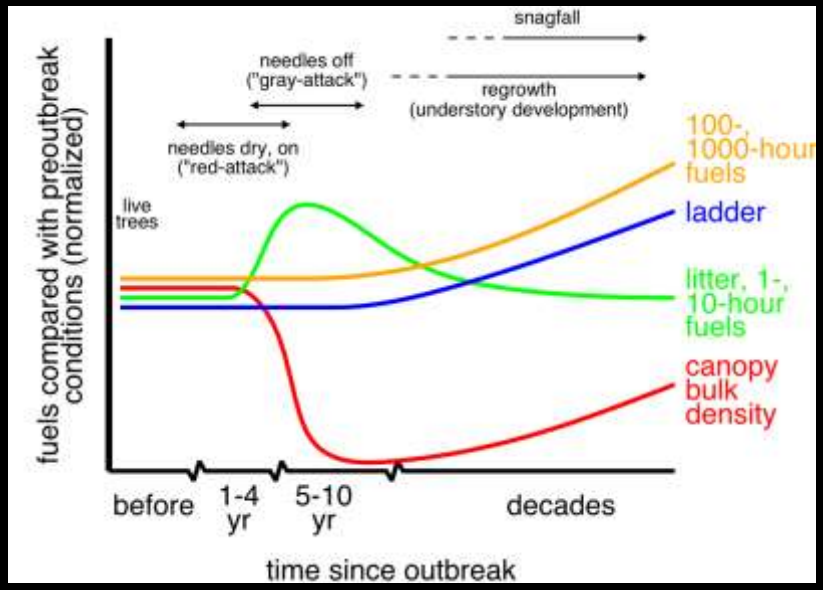


Potential explanations for disagreement among studies and with conceptual framework

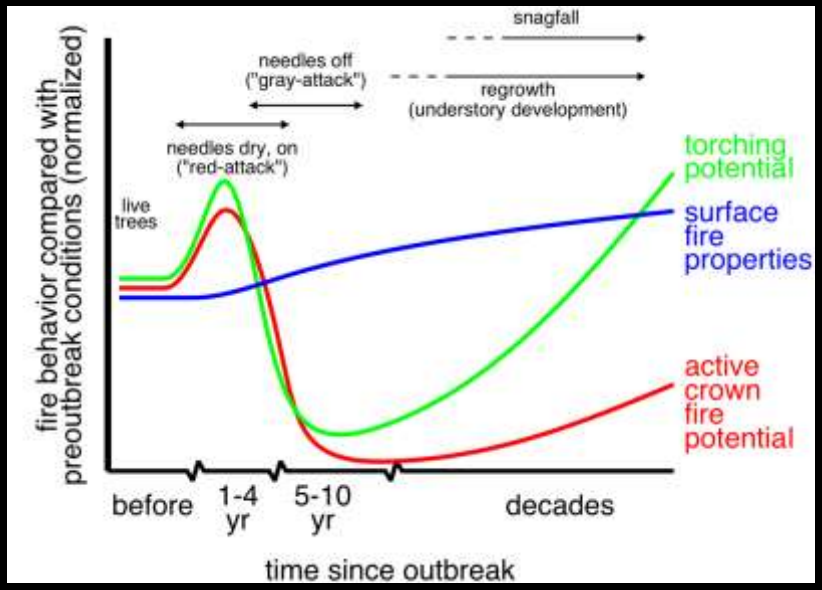
2. Studies ask different questions
   a) what are the most important drivers of wildfire characteristics?

   b) what is the fire behavior in beetle-killed stands relative to unattacked stands?

Fuel characteristics



Fire characteristics



Potential explanations for disagreement among studies and with conceptual framework

3. Stands are often mixtures of green, red, and gray trees

Simard et al. (2011):

mixing caused

- high stand-average foliar moisture
- lower canopy fuel amount in red-attack stage
- higher canopy fuel amount in gray-attack stage

All reduced beetle impacts on fire behavior…

Potential explanations for disagreement among studies and with conceptual framework

4. Variability in number of trees killed within a stand

Is “red-attack” 10% killed trees? 80%?

Potential explanations for disagreement among studies and with conceptual framework

5. Variability in fuels conditions in undisturbed stands

…makes detecting effect of beetle-kill more difficult

Digital Photo Series, Natural Fuels Photo Series, USFS, depts.washington.edu/nwfire/dps/

Additional important effects of beetle-killed trees

1. Beetle-killed trees extend the burning conditions

   - effect at intermediate wind speeds (Simard et al. 2011)
     - low wind: no simulated stands burned
     - high wind: all simulated stands burned

   - effect in moister (less dry) fuels
     - early in fire season (Steele and Copple 2009)
     - less extreme drought conditions




Additional important effects of beetle-killed trees

2. Fires are not inevitable in the first decades following a beetle outbreak

Photo by Matt Stensland
www.steamboatpilot.com/news/2008/aug/17/dying_forests_increase_wildfire_danger_across_west

Major gaps in scientific understanding

1. Fuels and fire behavior in red-attack stages

   a. how does fire behavior vary with different amounts of mortality?

Major gaps in scientific understanding

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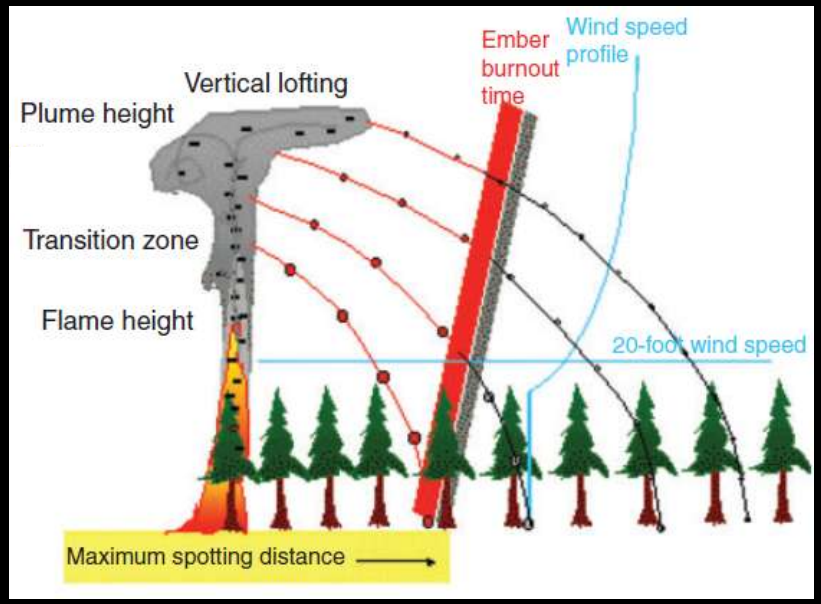
a. how does fire behavior vary with different amounts of mortality?

b. firebrand production, spotting

www.kdvr.com/news/kdvr-wildfire-forecasting-weather-20110321,0,3439015.story



BehavePlus, Koo et al. 2010

Major gaps in scientific understanding

1. Fuels and fire behavior in red-attack stages

a. how does fire behavior vary with different amounts of mortality?

b. firebrand production, spotting

c. very few experiments

Major gaps in scientific understanding

1. Fuels and fire behavior in red-attack stages

a. how does fire behavior vary with different amounts of mortality?

b. firebrand production, spotting

c. very few experiments

d. difficulty of representing in common fire behavior models

FFE-FVS

Major gaps in scientific understanding

2. Studies of postoutbreak stand dynamics

Rates of and controls on

- needlefall
- snagfall
- seedling establishment
- regrowth

How fast do stands progress through attack stages?




Major gaps in scientific understanding

3. Better understanding in different forest types

   Most studies in lodgepole pine and spruce

   Need

   - ponderosa pine
   - pinyon pine

William M. Ciesla, Forest Health Management International, Bugwood.org

Craig Allen, USGS

Major gaps in scientific understanding

4. Use of personal observations/anecdotes

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Beetle-ravaged trees change wildfire behavior in western Montana

Story Discussion Font Size:

By ROB CHANEY of the Missoulian | Posted: Sunday, October 4, 2009 8:45 am | (4) Comments

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A look at western Montana's major wildfires of 2009

What Tyler Brothers saw out his helicopter window last week sounds like the plot of an old melodrama.

He was flying 1,000 feet above the Bielenburg forest fire east of Deer Lodge, and he couldn't see the flames. The fire had boiled up, but cloaked itself so no one could see its boundary or direction. Half a dozen campers were down in the forest, surrounded by red beetle-killed trees and cut off from the firefighters.

"It's fire behavior you don't see too often," Brothers said of the Bielenburg's season finale. And it's fire behavior that's giving U.S. Forest Service land managers a lot to think about this winter.

In the last week of September, at least six big forest fires made major runs across western Montana. Several of them tripled or quadrupled their acreage in one or two days of rampage. The Bielenburg jumped from 188 acres to 1,956. A frequent factor was the presence of "red-and-dead" beetle-killed trees that burned from crown to crown, sending firefighters scrambling to find safety.

What Tyler Brothers saw out his helicopter window last week sounds like the plot of an old melodrama.

...

"It's fire behavior you don't see too often," Brothers said of the Bielenburg's season finale.

Categories of postoutbreak attack stage

- useful for conceptualizing effects
- limiting because
  - most stands not pure red or pure gray or …
  - gray-attack stands may have less or more canopy fuels
- similar problems with “time since outbreak”…just a surrogate for fuelbed characteristics

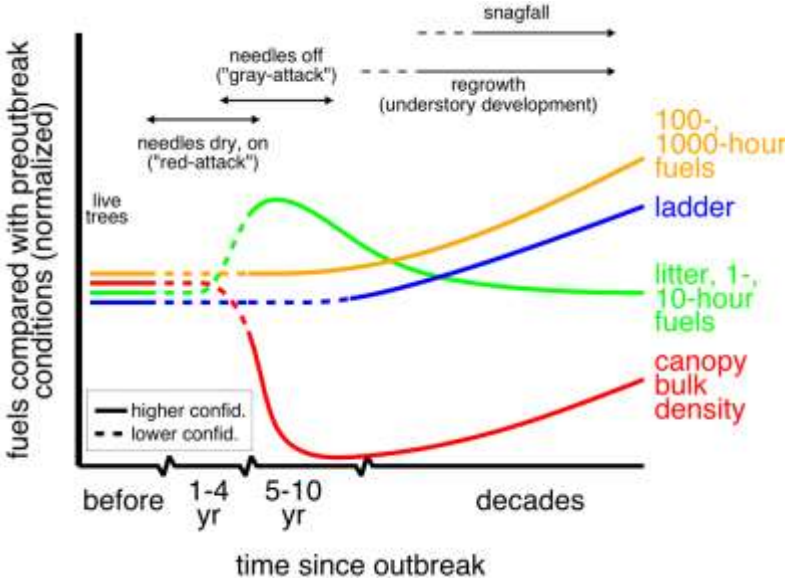


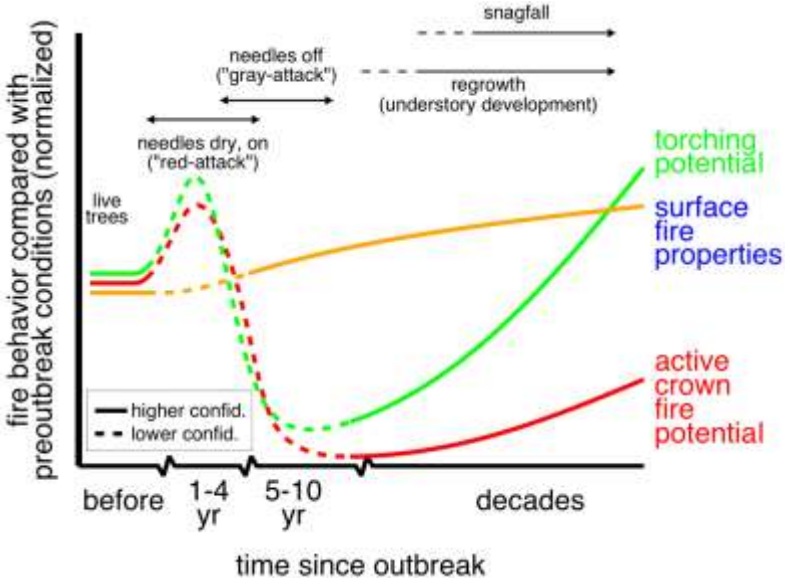

Summary and conclusions

- large changes in fuel and fire occur for years after beetle outbreaks
- disagreement exists in published literature and with conceptual framework
  - some reconciliation with specificity about
    - time since outbreak
    - fuels/fire characteristic
    - study question
- several key gaps in knowledge
  - most important: wildfire behavior in red-attack
- stay tuned for next talks

Photo by Matt Stensland

www.steamboatpilot.com/news/2008/aug/17/dying_forests_increase_wildfire_danger_across_west


fuels compared with preoutbreak conditions (normalized)
snagfall
needles off ("gray-attack")
regrowth (understory development)
needles dry, on ("red-attack")
live trees
100-, 1000-hour fuels
ladder
litter, 1-, 10-hour fuels
canopy bulk density
higher confid.
lower confid.
before
1-4 yr
5-10 yr
decades
time since outbreak


fire behavior compared with preoutbreak conditions (normalized)
snagfall
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live trees
torching potential
surface fire properties
active crown fire potential
higher confid.
lower confid.
before
1-4 yr
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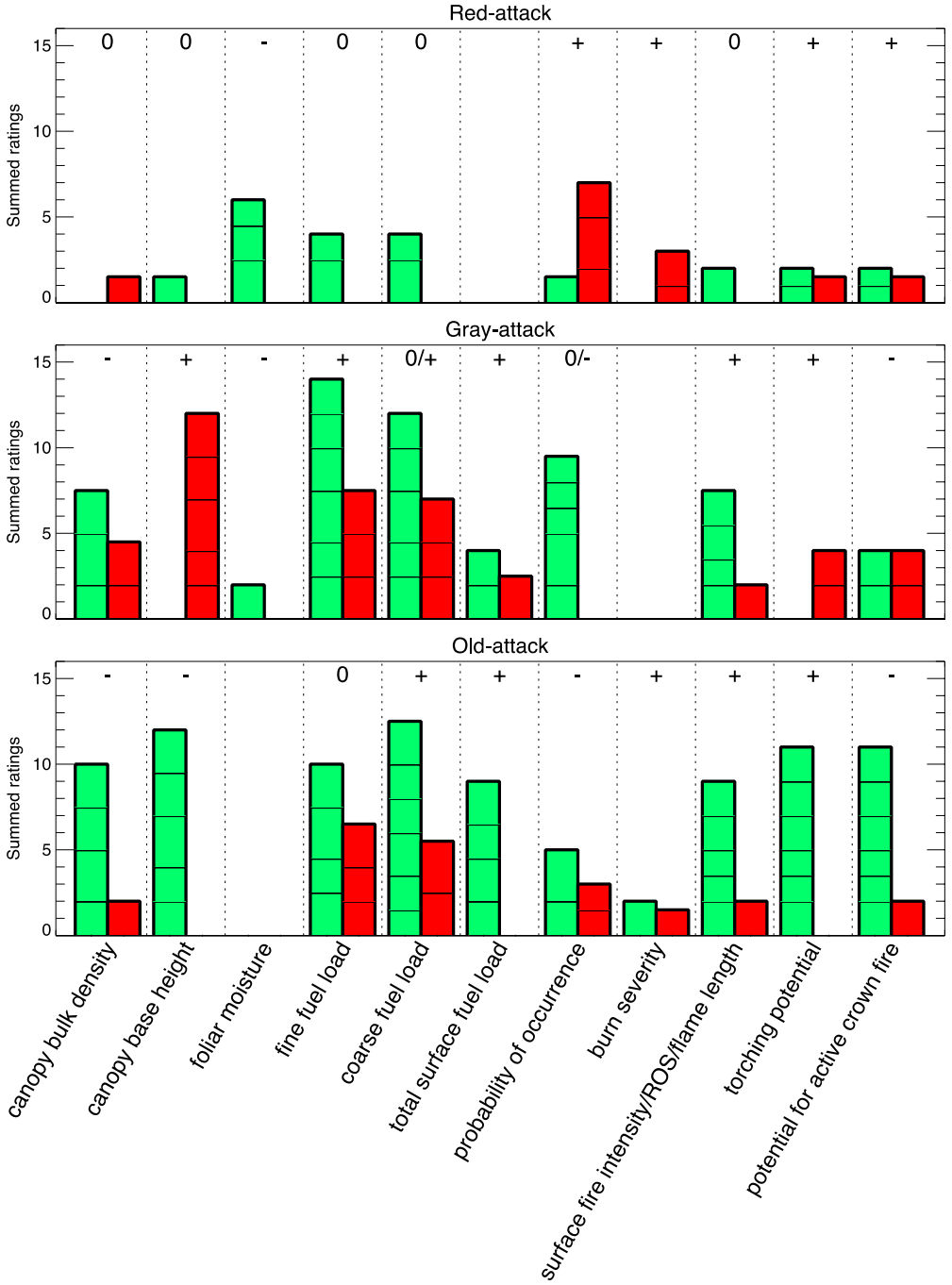
Red-attack
Gray-attack
Old-attack
Summed ratings
0 5 10 15
0 0 - 0 0 + + 0 + +
- + - + 0/+ + 0/- + + -
- - 0 + + - + + + -
canopy bulk density
canopy base height
foliar moisture
fine fuel load
coarse fuel load
total surface fuel load
probability of occurrence
burn severity
surface fire intensity/ROS/flame length
torching potential
potential for active crown fire